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ABSTRACT

This is the final report of the evaluation of Project CAUSE, a three year project to improve the laboratory portions of undergraduate physics courses at North Texas State University. The report is divided into six sections. Included in the overview are goals and purposes, the instructional format, and the evaluation plan. Demographic profiles comprise the second section. Section three includes the cognitive results and trends. A discussion of the affective results is included in the fourth section. Anecdotal observations, based on interactions between the evaluator and the project staff, are discussed in section five. Section six is a summary of conclusions and recommendations. A measurement instrument of the affective domain is given in the appendix. (SA)

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A Three Year Project to Improve the Instruction of Physics

Conducted by: The Department of Physics
North Texas State University

Sponsored by: The National Science Foundation

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Final Evaluation
Project CAUSE
1976 - 1979

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August, 1979

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SECTION I

OVERVIEW

This Final Evaluation Report represents a quantitative and qualitative assessment of the National Science Foundation sponsored Project CAUSE. This three year project has been conducted by the faculty and staff of the Department of Physics, North Texas State University.

In order to objectively assess the quality and effectiveness of the CAUSE project at NTSU, the Center for Research and Evaluation obtained demographic, cognitive, and affective measures from physics students. The following report describes the evaluative techniques utilized and the resultant findings gathered during the three year grant period.

GOALS

Project CAUSE at North Texas State University had the overall goal of rejuvenating and improving the laboratory portions of several undergraduate Physics courses. The courses designated were the service courses, those courses designed for non-science majors. The specific stated goals of the project were:

1) To increase the students' understanding of the basic natural laws central to the study of Physics.
2) To improve the attitude of the student toward the study of science in general and physics in particular.

PURPOSE OF THE EVALUATION

The central purpose of this report was to draw inferences based upon quantitative measures determined to be indicative of the project goals. It should be noted that predetermined quantitative measures and analysis procedures frequently do not reflect many important findings of a large scale program. Such findings are often important to those wishing to replicate or extend similar programs.

Within space limitations and a need to be concise, a second purpose of this report was to discuss those observations and anecdotes which were deemed to appropriately reflect key elements of the project. It is hoped that this discussion will be of benefit to those concerned with the improvement of instruction.

APPROACH

The instructional format of the laboratory service courses was modified to accommodate what was termed the Individualized Investigation Approach (IIA). The laboratory topics traditionally covered were organized into a series of investigations. The purpose of each investigation was to permit the student to independently utilize appropriate and effective audio-visual presentations of content followed by suggested opportunities to appropriately apply that content to experiments in physics.

Integral with the IIA was the development of the Physics Instructional Center (PIC). The PIC was a multi-media instructional resource library. Projectors, audio and color video

recorders, laboratory apparatus, along with an instructional materials library were available for student utilization within the PIC. The PIC was operational during normal class hours including some evenings.

Students were allowed to complete investigations on an open schedule. Upon reporting to the PIC, students were given written instructions and necessary instructional materials. Each student was responsible for the independent written completion of an investigation. Students were permitted to utilize all instructional equipment which enabled them to observe and review instructions as they deemed necessary. Teaching assistants were assigned to the PIC to assist students in the completion of investigations.

Upon completion of an investigation, each student was required to complete an examination. Grader/tutors were available to administer and evaluate examinations. The grader/tutor discussed the results of the examination with each student. Students failing to obtain the passing score of 80 per cent were given specific remediation tutoring. Failing students were then allowed to repeat the necessary portions of the investigations before re-taking an examination at a later time.

It was also necessary to establish a learning materials production center during the project. This center located adjacent to the PIC, includes a video-tape studio and control room along with production facilities for various types of audio-visual materials. These materials are primarily for

providing individual instruction in the various individualized investigations.

PROJECT COURSES

The service courses and the descriptions of assummed student clientele for Project CAUSE were:

Physics 121-122. Physical Science: A two-semester sequence with lab: primarily for students majoring in Education.

121. Principles and applications of mechanics, beat, sound, light, electricity.

122. Principles and applications of atomic physics, chemistry, geology, astronomy.

Physics 131-132. General Physics (Non-technical): A two-semester survey course with lab taken by students to satisfy the physical science portion of the lab science requirement in the College of Arts and Sciences.

131. Qualitative treatment of Newton's laws of motion, gravitation; Einstein's special relativity; conservation of momentum and energy; temperature and heat; states of matter.

132. Vibrations and waves; electricity and magnetism; modern physics, quantum theory of atomic structure; nuclear physics; impact of physics on society.

Physics 141-142. General Physics (Without Calculus): A two-semester sequence with lab, designed for majors in the life sciences.

141. Principles and applications of mechanics, sound, and beat.

142. Principles and applications of electricity, magnetism, light and atomic physics.

Physics 171-172. General Technical Physics (With Calculus): A two-semester sequence with lab; designed as a beginning course for majors in chemistry, mathematics, physics, and pre-engineering students.

171. Mechanics. Laws of motion, inertia, acceleration, force, energy, momentum, and angular momentum. Rotational and ascillatory motion. Gravitation.

172. Thermodynamics, Wave Motion, and Optics. Thermal properties of matter, laws of thermodynamics, temperature scales; wave motion and sound; reflection, refreaction, diffractions, interference of light.

EVALUATION PLAN

As stated above, the purpose of the project was to improve the student laboratory experience in the Physics service courses. The evaluation plan to accommodate this purpose called for the measurement of students in the affective and cognitive areas. In addition, a number of demographic variables were identified to describe each of the individual service class populations.

Two modifications of the proposed evaluation plan should be noted. First, the time necessary for the development, testing, and refinement of the audio-visual materials was extensive. This was due to the widely varied student populations in each service course and the subsequent differences which had to be met in the varied learning materials. Consequently, Physics 141 and 171 students were not included as target populations in this evaluation report.

Secondly, it was impossible to employ a regression analysis model due to the high student attrition rate and problems encountered in identifying specific student scores. This problem prevented the necessary matching of demographic characteristics and other predictive variables. To overcome these difficulties alternative statistical procedures were employed. These procedures are described within later sections

of this report.

DATA COLLECTION

The data collection was completed by staff members of the Center for Research and Evaluation. Personnel of the Physics Department were largely disassociated from testing procedures in order to avoid bias in the collection of data to be utilized in this summative report.

The instruments utilized in collecting the data included the following:

1. An affective instrument developed by the Center for Research and Evaluation staff;
2. a demographic characteristics survey;
3. the Dunning-Abeles Physics Test, and;
4. the Localized Cognitive Test which was an adaptation of the Dunning-Abeles Physics Test modified to meet local needs.

The overall plan of evaluation provided for the collection of data at three time intervals in each of the three years of the project (See TABLE I). This data collection plan permitted a "pre" data collection at the beginning of each Fall semester utilizing all of the instruments described above. A second data collection was conducted at the end of each Fall and Spring semester utilizing affective and cognitive instruments only.

In addition, various kinds of "feedback" or process-type data were collected. Included in these collections were questionnaires concerning the efficacy of the tapes and other learning materials. These data were collected by project staff to assist in the refinement of materials. While some of

the analyses were included in the Year Two Report, it was felt that due to its formative nature, process data would not be included in the Final Report.

TABLE I

DATA COLLECTION INTERVALS

	FALL	WINTER	SPRING
Year I 1976-77	X	X	X
Year II 1977-78	X	X	X
Year III 1978-79	X	X	X

ORGANIZATION

The report is divided into the following sections:

SECTION I
OVERVIEW

SECTION II
DEMOGRAPHIC PROFILES

SECTION III
COGNITIVE RESULTS AND FINDINGS

SECTION IV
AFFECTIVE RESULTS AND FINDINGS

SECTION V
ANECDOTAL OBSERVATIONS AND FINDINGS

SECTION VI
CONCLUSIONS AND RECOMMENDATIONS

SECTION II

DEMOGRAPHIC PROFILES

This section of the final report contains a presentation of an overall comparison of all measures collected since the beginning of the project. The student demographic variables are presented by class in Tables IA, IB, IC, and ID. From data in Table IA, the reader may obtain a listing of the demographic variables for students enrolled in Physics 121, and may compare Fall 1976 to Fall 1977 and Fall 1978. From data in Tables IB, IC, and ID, the reader may compare the student demographic variables collected in Year I, Year II, and Year III for the Physics 131, 141, and 171 courses, respectively.

The college major variable was reported differently in the final report than in previous evaluation reports. Education majors were grouped under one heading, Education, while science majors are listed by specific titles, such as Chemistry, Biology, and Physics. Total Science major frequencies were reported along with the specific major. These alterations in reporting were felt to provide a more descriptive demographic profile.

The Fall, 1978 profile closely paralleled previous data. Physics 121 again had more females enrolled than any of the other courses reported. This statistic can be attributed to the large percentage of education majors whom are enrolled in Physics 121. A decreasing number of women are found in Physics 131, 141, and 171.

Education majors made up the majority of students enrolled in Physics 121 (56.6%). This was to be expected since Physics 121 is designed to meet some of the needs of Education majors. Business students comprised the second largest group in Physics 121 (28.3%). This pattern is consistent with previous data collection results.

Education majors were also the largest group enrolled in Physics 131 (44.3%). Business and Social Science majors followed at 22.1% and 12.1% respectively. This pattern also follows previous results. A large number of studetns, 14.3% labeled themselves undecided as far as college major is concerned.

The majority of students enrolled in Physics 141 in 1978 were science majors (75.1%) with most of them indicating a major in Biology (41.7%). In past years a larger number of Education majors have been enrolled in Physics 141 but they appear to have been steered toward more appropriate courses this year.

A majority of Science majors were enrolled in Physics 171 over the three year period. The 1978 data collection period indicates that of the 59.1% Science majors, 21.2% were Physics, 19.7% Chemistry, and 12.1% Biology. A surprisingly high number (19.7%) identified themselves as Business majors while 16.7% were reported as undecided.

The largest number of freshmen were enrolled in Physics

121, however, Physics 131 enrolled the highest percentage of freshmen (50.0%). These two courses had a fairly even number of sophomores and juniors which followed the pattern recorded in previous years. Ths highest percentage of juniors were enrolled in Physics 141 (36.8%) and the highest percentage of sophomores (35.4%) were found in Physics 171. This data is also consistent with Year I and Year II measures.

The majority of Physics 121 students had no previous physics or chemistry courses in high school. This was also true for Physics 131 studetns and closely paralleled past demographic profiles. A large number (53.1% and 43.9%) of students enrolled in Physics 141 and 171 also had no previous physics in high school while a majority of these students did have at least one full year of chemistry. Most students in all courses, reported having taken Algebra and Geometry in high school but more students in Physics 141 and 171 reported having taken math courses in college than students enrolled in 121 or 131.

The ethnic groups closely paralleled the overall campus population. This data is found in TABLE IE. A large majority of the students came from large suburban/urban cities. The profiles closely approximates the total university population.

The number of handicapped students receiving instruction under the grant also closely paralleled the overall campus population. The Physics Instructional Center moreover, was designed to accommodate students with various physical handicaps. The handicapped population data is found in TABLE IE.

From this summary of demographic results it may be observed that each of the student populations were not altered appreciably in composition throughout the three year observation period. Additionally, the provision of service courses was successful in enrolling students with areas of study appropriate to the specific course content.

TABLE 1A

RESPONCES TO DEMOGRAPHIC QUESTIONS BY FREQUENCY AND PERCENT - PHYSICS 121

VARIABLE	FALL 1976		FALL 1977		FALL 1978	
	FREQUENCY	PERCENT	FREQUENCY	PERCENT	FREQUENCY	PERCENT
SEX:						
Male	72	33.6	100	37.0	53	26.8
Female	142	66.4	174	63.0	145	73.2
MARITAL STATUS:						
Single	179	83.6	245	89.4	166	83.8
Married	28	13.1	27	9.7	28	14.1
Divorced or Separated	5	2.3	2	.9	3	1.5
COLLEGE MAJOR						
Education	120	56.1	89	32.0	112	56.6
Business	78	36.4	87	31.0	56	28.3
Social Science	3	1.4	9	3.0	15	7.6
English	11	5.1	19	7.0	1	.5
Science					1	.5
Biology					1	.5
Undecided					9	4.5
YEAR IN COLLEGE:						
Freshman	108	50.5	170	62.9	95	48.0
Sophomore	47	22.0	40	14.5	40	20.2
Junior	42	19.6	40	14.5	41	20.7
Senior	17	7.9	17	6.0	19	9.6
Graduate			5	1.8		

TABLE 1A (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
ETHNIC GROUP:						
White	165	77.1	216	81.2	162	81.8
Black	22	10.3	31	11.6	19	9.6
Mexican-Am	11	5.1	7	2.6	6	3.0
Asian	4	1.9	5	1.9	3	1.5
Other	2	.9	7	2.6	3	1.5
NATIONALITY:						
American	209	97.7	259	98.5	192	97.0
Foreign Student	4	1.9	4	1.5	4	2.0
SIZE OF HOME TOWN:						
Rural	40	18.7			37	18.7
Urban	84	39.2			99	50.0
Suburban	87	40.6			57	28.8
PREVIOUS PHYSICS IN HIGH SCHOOL:						
None	154	72.0	151	55.9	114	57.6
1 Semester	9	4.2	15	5.5	16	8.1
1 Full Year	42	19.6	95	35.2	63	31.8
More than 1 year	5	2.3	9	3.3	3	1.5
PREVIOUS CHEMISTRY IN HIGH SCHOOL:						
None	120	56.1	169	62.4	122	61.6
1 Semester	9	4.2	15	5.5	17	8.6
1 Full Year	77	36.0	84	30.9	53	26.8
More than 1 year	3	1.4	3	1.1	2	1.0

TABLE 1A (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
PREVIOUS PHYSICS IN COLLEGE:						
None	196	91.6	262	95.3	182	91.9
1 Semester	16	7.5	8	2.9	10	5.1
1 Full year			5	1.8	4	2.0
More than 1 year						
PREVIOUS CHEMISTRY IN COLLEGE:						
None	204	95.3	269	98.5	186	93.9
1 Semester	3	1.4	4	1.5	4	2.0
1 Full year	1	.5			3	1.5
More than 1 year						
PREVIOUS MATH IN HIGH SCHOOL:						
General	59	27.6	89	31.7	70	35.4
Algebra	195	91.1	243	86.5	169	85.4
Geometry	176	82.2	235	83.6	145	73.2
Advanced Alg.	64	29.9	73	25.9	61	30.8
Other	57	26.6	58	20.6	37	18.7
COLLEGE HOURS IN MATHEMATICS:						
None	138	64.5	213	75.8	129	65.2
3	47	22.0	36	12.8	32	16.2
6	21	9.8	21	7.5	25	12.6
7	1	.5				
9	5	2.3	6	2.1	6	3.0
12	1	.5	3	1.1	2	1.0
15	1	.5	1	.7	1	.5
18						

TABLE IA (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
COLLEGE HOURS IN STATISTICS:						
None	200	93.5	259	92.2	182	91.9
3	9	4.2	7	2.5	6	3.0
6	3	1.4	3	1.1	2	1.0
9	1	.5	1	.4		
10			2	.7	2	1.0
12			9	3.2		
15					5	2.5
16 or more						

TABLE IB

RESPONSES TO DEMOGRAPHIC QUESTIONS BY FREQUENCY AND PERCENT - PHYSICS 131

	FALL 1976		FALL 1977		FALL 1978	
VARIABLE	FREQUENCY	PERCENT	FREQUENCY	PERCENT	FREQUENCY	PERCENT
SEX·						
Male	80	55.9	74	53.6	78	55.7
Female	63	44.0	64	46.4	62	44.3
MARITAL STATUS·						
Single	123	86.0	115	85.8	117	83.6
Married	18	12.6	15	11.2	19	13.6
Divorced or Separated	1	.7	4	3.0	1	0.7
COLLEGE MAJOR·						
Education	69	48.3	73	52.9	62	44.3
Business	18	12.6	21	15.2	31	22.1
Social Science	16	11.2	8	5.8	17	12.1
English	26	18.2	24	17.4	5	3.6
Science					2	1.4
Physics					1	.7
Biology					1	.7
Undecided					20	14.3
YEAR IN COLLEGE·						
Freshman	62	43.4	65	47.1	70	50.0
Sophomore	44	30.8	29	21.0	34	24.3
Junior	24	16.8	33	23.9	26	18.6
Senior	13	9.0	10	7.2	10	7.1
Graduate			1	.7	0	0

TABLE 18 (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
ETHNIC GROUP:						
White	122	85.3	109	81.9	111	79.3
Black	7	4.9	16	12.0	15	10.7
Mexican-Am	5	3.5	5	3.7	4	2.9
Asian	3	2.1	1	.7	4	2.9
Other	2	1.4	2	1.5	1	.7
NATIONALITY:						
American	135	94.4	136	98.5	128	91.4
Foreign Student	7	4.9	2	1.5	10	7.1
TYPE HIGH SCHOOL:						
Rural	31	21.7	26	18.8	23	16.4
Urban	64	44.8	78	56.5	75	53.6
Suburban	43	30.0	33	23.9	39	27.9
PREVIOUS PHYSICS IN HIGH SCHOOL:						
None	112	78.3	115	83.9	103	73.6
1 Semester	7	4.9	8	5.8	8	5.7
1 Full Year	18	12.6	11	8.0	24	17.1
More than 1 year	6	4.2	3	2.2	3	2.1
PREVIOUS CHEMISTRY IN HIGH SCHOOL:						
None	82	57.3	73	53.6	74	52.9
1 Semester	10	7.0	10	7.3	14	10.0
1 Full Year	43	30.0	49	36.0	44	31.4
More than 1 year	8	5.6	4	2.9	5	3.6

TABLE IB (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
PREVIOUS PHYSICS IN COLLEGE:						
None	133	93.0	126	91.0	122	87.1
1 Semester	7	4.9	7	5.1	14	10.0
1 Full year	1	.7	4	2.9		
More than 1 year	1	.7			1	.7
PREVIOUS CHEMISTRY IN COLLEGE:						
None	129	90.2	126	93.3	130	92.9
1 Semester	4	2.8	4	2.9	2	1.4
1 Full year	7	4.9	4	2.9	2	1.4
More than 1 year	2	1.4	1	.7		
PREVIOUS MATH IN HIGH SCHOOL:						
General	55	38.5	52	37.7	47	33.6
Algebra	121	84.6	116	84.1	124	88.6
Geometry	114	79.7	97	70.3	105	75.0
Advanced Alg.	42	29.4	42	30.4	42	30.0
Other	38	26.6	33	23.9	39	27.9
COLLEGE HOURS IN MATHEMATICS:						
None	88	61.5	92	66.7	99	70.7
3	27	18.9	30	21.7	29	20.7
6	18	12.6	12	8.7	8	5.7
7						
9	4	2.8				
12	5	3.5	3	2.2	3	2.1
15	1	.7	1	.7		
18						

TABLE IB (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
COLLEGE HOURS IN STATISTICS:						
None						
3	137	95.8	117	84.8	132	94.3
6	2	1.4	12	8.7	6	4.3
9	2	1.4	5	3.6	1	0.9
10	1	.7				
12			1	.7		
15			3	2.2		
16 or more					1	0.7

TABLE IC

RESPONSES TO DEMOGRAPHIC QUESTIONS BY FREQUENCY AND PERCENT - PHYSICS 141

	FALL 1976		FALL 1977		FALL 1978	
VARIALBE	FREQUENCY	PERCENT	FREQUENCY	PERCENT	FREQUENCY	PERCENT
SEX:						
Male	62	63.9	47	62.7	65	67.7
Female	35	36.1	28	37.3	31	32.3
MARITAL STATUS:						
Single	74	76.3	60	83.3	79	84.0
Married	19	19.6	12	16.7	11	11.7
Divorced or Separated	3	3.1	0	0.0	4	4.3
COLLEGE MAJOR:						
Education	22	22.6	15	20.0	1	1.0
Business	2	2.0	6	8.0	7	7.3
Social Science	1	1.0	5	9.0	3	3.1
English	3	3.1	4	5.3	0	0.0
Science	41	42.3	29	38.7	72	75.1
Physics					9	9.4
Chemistry					6	6.3
Medical Related					17	17.7
Biology					40	41.7
Undecided					12	12.5
YEAR IN COLLEGE:						
Freshman	8	8.2	8	10.7	9	9.5
Sophomore	32	33.0	27	36.0	27	28.4
Junior	44	45.4	32	42.7	35	36.8
Senior	9	9.3	5	6.7	20	21.1
Graduate	4	4.1	3	4.0	4	4.2

TABLE IC (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
ETHNIC GROUP:						
White	75	77.3	55	77.5	75	78.1
Black	11	11.3	5	7.0	6	6.3
Mexican-Am	1	1.0	1	1.4	2	2.0
Asian	4	4.1	7	9.8	5	5.2
Other	3	3.1	3	4.2	3	3.1
NATIONALITY:						
American	90	92.8	61	84.7	83	86.5
Foreign Student	6	6.2	11	15.3	12	12.5
TYPE HIGH SCHOOL:						
Rural	16	16.5	16	21.3	20	20.8
Urban	27	27.8	38	50.7	53	55.2
Suburban	53	54.6	18	24.0	20	20.8
PREVIOUS PHYSICS IN HIGH SCHOOL:						
None	60	61.8	43	57.3	51	53.1
1 Semester	5	5.1	8	10.7	5	5.2
1 Full Year	29	29.9	15	20.0	33	34.4
More than 1 year	3	3.0	9	12.0	7	7.3
PREVIOUS CHEMISTRY IN HIGH SCHOOL:						
None	17	17.5	16	21.3	14	14.6
1 Semester	9	9.3	7	9.3	9	9.4
1 Full Year	60	61.9	40	53.3	57	59.4
More than 1 year	11	11.3	12	16.0	16	16.7

TABLE IC (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
PREVIOUS PHYSICS IN COLLEGE:						
None	89	91.7	65	86.7	64	66.6
1 Semester	6	6.1	4	5.3	16	16.7
1 Full year	2	2.1	4	5.3	7	7.3
More than 1 year			2	2.7	8	8.3
PREVIOUS CHEMISTRY IN COLLEGE:						
None	16	16.5	24	32.0	19	19.8
1 Semester	10	10.3	12	16.0	8	8.3
1 Full year	33	34.0	25	33.3	34	35.4
More than 1 year	37	38.1	14	18.7	34	35.4
PREVIOUS MATH IN HIGH SCHOOL:						
General	9	9.3	17	22.7	20	20.8
Algebra	78	80.4	63	84.0	78	81.3
Geometry	83	85.6	67	89.3	86	89.6
Advanced Alg	42	43.3	37	49.3	56	58.3
Other	65	67.0	46	61.3	67	70.0
COLLEGE HOURS IN MATHEMATICS:						
None	6	6.2	13	17.3	10	10.4
3	21	21.6	17	22.7	19	19.8
6	45	46.4	24	32.0	36	37.5
7	1	1.0				
9	14	14.4	15	20.0	10	10.4
12	7	7.2	5	6.7	3	3.1
15	1	1.0	1	1.3	7	7.3
18					1	1.0

TABLE IC (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
COLLEGE HOURS IN STATISTICS:						
None	94	96.9	66	88.0	85	88.5
3	2	2.1	5	6.7	7	7.3
6	1	1.0	1	1.3		
9			2	2.7	1	1.1
10						
12						
15			1	1.3		
16 or more					2	2.1

TABLE ID

RESPONSES TO DEMOGRAPHIC QUESTIONS BY FREQUENCY AND PERCENT - PHYSICS 171

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
SEX:						
Male	49	81.7	45	70.3	46	70.8
Female	11	18.3	19	29.7	19	29.2
MARITAL STATUS:						
Single	53	88.3	53	82.8	55	83.3
Married	6	10.0	8	12.5	10	15.2
Divorced or Separated	1	1.7	3	4.7	1	1.5
COLLEGE MAJOR:						
Education	3	5.0	2	3.1	0	0
Business	0	0.0	2	3.1	13	19.7
Social Science	1	1.6	0	0.0	0	0
English	1	1.6	1	1.5	0	0
Science	50	83.3	55	85.9	39	59.1
Physics					14	21.2
Chemistry					13	19.7
Medical Related					4	6.1
Biology					8	12.1
Undecided	4	6.7	5	7.8	11	16.7
YEAR IN COLLEGE:						
Freshman	31	51.7	13	20.6	20	30.3
Sophomore	23	38.3	20	31.7	24	36.4
Junior	5	8.3	19	30.3	17	25.7
Senior	1	1.7	6	9.5	4	6.1
Graduate			5	7.9	1	1.5

TABLE ID (Continued)

VARIABLE	FALL 1976		FALL 1977		FALL 1978	
	FREQUENCY	PERCENT	FREQUENCY	PERCENT	FREQUENCY	PERCENT
ETHNIC GROUP:						
White	40	66.7	54	90.0	50	75.8
Black	3	5.0	4	6.7	4	6.1
Mexican-Am	1	3.5	0	0.0	2	3.0
Asian	7	11.7	1	1.6	5	7.6
Other	8	13.3	1	1.6	1	1.5
NATIONALITY:						
American	47	78.3	60	93.7	56	84.9
Foreign - Student	12	20.0	4	6.2	9	13.6
TYPE HIGH SCHOOL:						
Rural	9	15.0	2	28.6	11	16.6
Urban	24	40.0	5	71.4	32	48.5
Suburban	19	31.7	0	0.0	22	33.3
PREVIOUS PHYSICS IN HIGH SCHOOL:						
None	15	25.0	37	57.8	29	43.9
1 Semester	4	6.7	4	6.2	4	6.1
1 Full Year	26	43.4	21	32.8	22	33.3
More than 1 year	14	23.3	2	3.1	11	16.7
PREVIOUS CHEMISTRY IN HIGH SCHOOL:						
None	10	16.7	18	28.6	6	9.1
1 Semester	3	5.0	8	12.7	8	12.1
1 Full Year	34	56.7	31	49.2	33	50.0
More than 1 year	12	20.0	6	9.5	18	27.3

TABLE ID (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
PREVIOUS PHYSICS IN COLLEGE:						
None	51	85.0	56	88.9	55	83.3
1 Semester	6	16.0	6	8.9	9	13.6
1 Full year	2	3.3	1	1.6	1	1.5
More than 1 year						
PREVIOUS CHEMISTRY IN COLLEGE:						
None	31	51.7	20	31.7	31	47.0
1 Semester	12	20.0	4	6.3	3	4.5
1 Full year	12	20.0	20	31.7	15	22.7
More than 1 year	3	5.0	19	30.0	15	22.7
PREVIOUS MATH IN HIGH SCHOOL:						
General	12	20.0	12	18.7	17	25.6
Algebra	51	85.0	55	85.9	56	84.8
Geometry	50	83.3	54	84.4	58	87.9
Advanced Alg	44	73.3	33	51.6	46	20.0
Other	52	86.7	48	75.0	51	77.3
COLLEGE HOURS IN MATHEMATICS:						
None	23	38.3	17	26.6	18	27.3
3	11	18.3	11	17.2	11	16.7
6	13	21.7	17	26.6	13	19.7
7					1	1.5
9	5	8.3	9	14.1	10	15.2
12	6	10.0	8	12.2	4	6.1
15	1	1.7	2	3.1	4	6.1
18	1	1.7			2	3.0

TABLE ID (Continued)

VARIABLE	FALL 1976 FREQUENCY	FALL 1976 PERCENT	FALL 1977 FREQUENCY	FALL 1977 PERCENT	FALL 1978 FREQUENCY	FALL 1978 PERCENT
COLLEGE HOURS IN STATISTICS:						
None	3	5.0	60	93.7	63	95.5
3	3	5.0	3	4.7	2	3.0
6						
9	3	5.0				
10	4	6.7				
12			1	1.6		
15	11	19.4				
16 or more						

TABLE IE

COMPARISONS OF KEY DEMOGRAPHICS
UNIVERSITY/PHYSICS STUDENT VARIABILITY
FOR SPRING, 1979

VARIABLE	FREQUENCY	PERCENTAGE	PHYSICS PERCENTAGE
Sex:			
Male	8,798	50.9	48.4
Female	8,502	49.1	51.5
Ethnic Groups (Undergraduate)			
White	10,279	84.0	78.75
Black	1,283	10.0	8.175
Mexican-American	388	3.1	2.725
Asian	238	1.9	4.3
Other	43	.29	1.7
Handicapped	160	.9	1.4

SECTION III

COGNITIVE RESULTS AND FINDINGS

As indicated within Section I of this report, it will be a purpose of this report to infer the efficacy of Project CAUSE in attaining its goals. The first goal of the NTSU project was "to increase the students' understanding of the basic natural laws central to the subject of Physics." This goal deals directly with learning achievement or cognitive change. The concept of understanding also connotes some degree of cognitive awareness beyond the simple recall of facts. Success in the attainment of an objective is frequently gauged solely upon cognitive increments. It should be noted that when combined with other positive factors (e.g., attitude, comprehension, retention) minimal measured student cognitive change may also be acceptable while a significant decline in measured cognition would prove unacceptable.

The Dunnings-Abeles Physics Test (DAPT) published by Harcourt, Brace and World, was used to measure the cognitive area. This test is a 50 item multiple choice test with two equivalent forms. It purports to measure knowledge, comprehension, and application of five areas commonly taught in high school Physics class. These areas are: mechanics, electricity and magnetism, atomic and nuclear physics, wave motion and light, and kinetic-molecular theory.

The test was standardized on a national population. Content validity was checked by comparing the test's stated content and

objectives to those of each service course. Reported split-half reliability coefficients range from .78 to .91. This test was selected for use because of its rigid development, its readability for beginning college students and the equivalent forms. The equivalent forms were used at alternate administration times.

The first year of the project can be described as a base-line data collection period. During this period the Project staff devoted their collective efforts to planning and production of materials. The cognitive evaluation data was collected utilizing the Dunning-Abeles Physics Test as a basis for future comparison. This data may be found in TABLE II. An Analysis of Variance "F-ratio" was calculated to determine similarity between the four service course populations. Inspection of those comparisons determined that the populations were considerably different ($p < .0001$) in terms of entering awareness and subsequent achievement in Physics subject matter.

TABLE II

MEANS AND STANDARD DEVIATIONS
OF COGNITIVE MEASURE
YEAR I

	FALL, 1976			WINTER, 1976			SPRING, 1977		
CLASS	$\bar{X}$	S.D.	F	$\bar{X}$	S.D.	F	$\bar{X}$	S.D.	F
121/122	9.8	4.5		16.90	5.9		16.0	6.10	35.444
131/132	10.1	5.9	55.847	14.50	6.3		22.2	7.50	(p<.0001)
141/143	16.5	6.4	(p<.0001)	21.20	6.9	20.176	20.8	14.10	
171/172	18.5	8.9		23.6	10.2	(p<.0001)	30.9	9.3	

The above findings along with the demographic profiles lead to the project staff decision to develop different learning materials for the service courses. The decision to vary the materials for the courses was based upon the divergence in student populations between the four service courses. Physics 121 and 131 were selected as the target service courses for full implementation by the end of the third project year. It should be further noted that to allow for continuing development of instructional materials only partial implementations of materials took place during the second project year for Physics 121 and 131 students. Full implementation of instructional materials was initiated in the third year. Continuing refinement is planned for the future.

TABLE III

MEANS AND STANDARD DEVIATIONS
OF COGNITIVE MEASURE
YEAR II

	FALL, 1977		WINTER, 1977		SPRING, 1978	
CLASS	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
121/122	9.51	4.45	18.76	6.10	15.10	5.90
131/132	10.44	4.91	13.82	5.68	21.04	7.13
141/142	18.60	7.60	20.0	7.20	26.20	10.40
171/172	19.0	6.0	25.70	7.90	31.30	19.80

TABLE IV

MEANS AND STANDARD DEVIATIONS
OF COGNITIVE MEASURE
YEAR III

	FALL, 1978		WINTER, 1978		SPRING, 1979	
CLASS	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
121/122	12.30	5.24	16.64	6.03	17.98	5.95
131/132	13.74	6.02	16.32	5.91	23.50	4.66
141/142	19.10	7.40	22.30	7.30	26.80	7.37
171/172	24.30	9.80	24.40	10.10	31.10	10.20

TABLES III and IV contain means and standard deviations from the DAPT instrument during the second and third project years. Comparison of the data between the two tables permitted the following observations. Some variations appeared to take place between the Physics 121 and 131 mean scores during Year II, while the Physics 141 and 171 students cognitive scores remained relatively stable.

Since Physics 121 and 131 students were deemed the initial Year II and III target populations, a more detailed analysis was conducted upon the data collected from these classes. Observation of the data in TABLE V and VI indicated that some significant differences existed between achievement in each of the three projects years. The Analysis of Variance was utilized to determine the "F-ratio" for all group means during each year. A Tukey HSD test was utilized to compare mean scores for each

group within each class and year. Inspection of the results of the comparisons indicated that all group means differed with a $p < .0001$ probability level.

TABLE V

DUNNING-ABELES TEST GROUP MEAN COMPARISONS DURING EACH PROJECT CAUSE YEAR FOR PHYSICS 121 STUDENTS BY ONE WAY ANALYSIS OF VARIANCE AND TUKEY'S HSD TEST

	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
YEAR I					
Fall, 76	198	9.682	4.476	66.153	F≠W
Winter, 76	121	16.554	6.666	p<.0001	F≠S
Spring, 77	70	15.114	5.904		W=S
YEAR II					
Fall, 77	283	9.512	4.454	166.843	F≠W
Winter, 77	147	18.768	6.103	p<.0001	F≠S
Spring, 78	90	16.111	5.968		W≠S
YEAR III					
Fall, 78	198	12.308	5.240	22.602	F≠W
Winter, 78	108	16.648	6.031	p<.0001	F≠S
Spring, 79	50	14.500	4.789		W=S

Fall (F)
Winter (W)
Spring (S)

TABLE VI

DUNNING-ABELES TEST GROUP MEAN COMPARISONS
DURING EACH PROJECT CAUSE YEAR FOR
PHYSICS 131 STUDENTS BY ONE WAY
ANALYSIS OF VARIANCE AND TUKEY"S
HSD TEST

	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
YEAR I					
Fall, 76	137	10.482	5.922	29.014	F≠W
Winter, 76	77	14.221	6.605	p<.001	F≠S
Spring, 77	29	19.828	7.383		W≠S
YEAR II					
Fall, 77	139	10.438	4.905	30.685	F≠W
Winter, 77	77	13.818	5.674	p<.001	F≠S
Spring, 78	28	18.464	6.040		W≠S
YEAR III					
Fall, 78	138	13.739	6.022	31.255	F≠W
Winter, 78	84	16.321	5.905	p<.0001	F≠S
Spring, 79	26	23.500	4.649		W≠S

Fall (F)
Winter (W)
Spring (S)

Further inspection of the Tukey comparisons in TABLES V and VI indicated that only the Physics 121 Winter and Spring Tukey HSD mean comparisons did not differ significantly for Year I and III. Inspection of Figure I assisted in determining that Physics 121 (Spring) content is largely not covered by the DAPT instrument. The finding that no significant difference existed for the Physics 121/122 students in the two years discussed above was an indication that cognitive retention of learning might have been present.

FIGURE I

CONTENT OF COGNITIVE TEST COVERED
BY SERVICE COURSES

	121 (Fall)	122 (Spring)	131 (Fall)	132 (Spring)
Mechanics	X	X	X	X
Electricity and Magnetism	X			X
Wave Motion and Light	X			X
Atomic and Nuclear Physics	X	X	X	
Kinetic-Molecular	X		X	

The data presented in TABLES V and VI did not seem totally adequate for a relatively clear understanding of the impact of Project CAUSE upon student cognition. It was determined that further analysis should be conducted upon the student cognitive score data.

collected during each of the two implementation years (Year II and III). This analysis considered the five subject matter subtest scores (See Figure I), and cognitive level (knowledge, understanding, and application) subtest scores.

Further, it was determined through a local content validity check and an item analysis that several of the DAPT items could be effectively eliminated. In order to make the instrument more appropriate to local needs, these items were dropped. The modified instrument was referred to as the Localized Cognitive Test (LCT).

TABLES VII and VIII may be inspected to compare LCT subtest score means for Year II and III Physics 121 students respectively. All groups differed ($p < .0001$) on each subtest as indicated by the Analysis of Variance "F" ratios. The Tukey HSD (Probability < .05) was utilized to determine the extent of differences within each subtest group. Significant Fall to Spring (F≠S) mean increment differences were noted on all subtest mean scores during Year II but fewer in Year III.

It should be noted that, while over-reliance upon the subtest scores may be questionable due to the size of some subtests, overall trends may be considered. One trend was that with the exception of the Mechanics subtest all other scores decreased between Year II Winter and Spring data collection. This may be partially attributable to the structure of the course, in that Mechanics along with Atomic and Nuclear Physics were the only topic measured by the DAPT and included during the Spring Physics 122 course offering.

The Winter-Spring cognitive score declines persisted but were not as great during the full implementation (Year III) phase of the project. Further, it should be noted that no decline (F=S) was significant (Tukey $P < .05$) in any of the Year III sub-tests mean scores while some scores increased slightly. This observation may bear indication of better student cognitive retention among Year III 121 students.

The above conjecture concerning retention was supported by the three cognitive level sub-tests. Both the knowledge and comprehension sub-scores did not decline statistically significant probability levels during the Year III Winter to Spring (W=S) period. Application scores increased in both project years for the Physics 121 students.

TABLES IX and X contain the LCT mean scores for Physics 131 students during the implementation years (Year II and Year III). A general inspection of the data revealed that the only decline in group means was in the Year III Fall-Winter Kinetic-Molecular mean scores and Application mean scores. All other mean scores were up. Most Year II and Year III gains, which were not statistically significant (Tukey $P < .05$), were accounted for by the sequence of the content average as depicted in Figure I. All Analysis of Variance "F" ratios indicate a statistically significant (Probability $< .0001$) difference within all subtest groups.

In summary, the Physics 121 and 131 courses appeared to produce some positive cognitive and no observable negative impact upon student cognitive scores. Some indicators appeared

to substantiate higher retention among Physics 121 students during Year III. Physics 131 students' cognitive scores seemed generally parallel for each implementation year. Generally all groups appeared to follow similar cognitive trends.

TABLE VII

LOCALIZED COGNITIVE TEST GROUP MEAN COMPARISONS
FOR YEAR 2 PHYSICS 121 STUDENTS BY ONE WAY
ANALYSIS OF VARIANCE AND TUKEY'S HSD TEST

SUB-TEST GROUP BY DATE	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
MECHANICS					
Fall, 77	283	2.025	1.423	28.408	F≠W
Winter, 77	147	3.054	1.658	p<.0001	F≠S
Spring, 78	90	3.156	2.044		W=S
ELECTRICITY AND MAGNETISM					
Fall, 77	283	2.897	1.676	68.419	F≠W
Winter, 77	147	4.932	1.911	p<.0001	F≠S
Spring, 78	90	4.411	2.055		W=S
WAVE MOTION AND LIGHT					
Fall, 77	283	1.187	0.977	112.831	F≠W
Winter, 77	147	2.993	1.550	p<.0001	F≠S
Spring, 78	90	2.211	1.213		W≠S
ATOMIC AND NUCLEAR PHYSICS					
Fall, 77	283	0.792	0.835	135.447	F≠W
Winter, 77	147	2.312	1.243	p<.0001	F≠S
Spring, 78	90	2.078	0.997		W=S
KINETIC-MOLECULAR					
Fall, 77	283	0.905	0.872	88.893	F≠W
Winter, 77	147	2.204	1.104	p<.0001	F≠S
Spring, 78	90	1.511	.997		W≠S
KNOWLEDGE					
Fall, 77	283	2.180	1.271	148.764	F≠W
Winter, 77	147	4.612	1.698	p<.0001	F≠S
Spring, 78	90	3.500	1.292		W≠S
UNDERSTANDING					
Fall, 77	283	3.435	2.088	150.928	F≠W
Winter, 77	147	7.823	2.937	p<.0001	F≠S
Spring, 78	90	5.878	3.027		W≠S
APPLICATION					
Fall, 77	283	2.191	1.532	43.326	F≠W
Winter, 77	147	3.061	1.768	p<.0001	F≠S
Spring, 78	90	3.989	1.893		W≠S
TOTAL TEST					
Fall, 77	283	7.806	3.587	172.362	F≠W
Winter, 77	147	15.497	5.087	p<.0001	F≠S
Spring, 78	90	13.367	4.898		W≠S

Fall (F)
Winter (W)
Spring (S)

TABLE VIII

LOCALIZED COGNITIVE TEST GROUP MEAN COMPARISONS FOR YEAR 3 PHYSICS 121 STUDENTS BY ONE WAY ANALYSIS OF VARIANCE AND TUKEY'S HSD TEST

SUB-TEST GROUP BY DATE	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
MECHANICS					
Fall, 78	198	2.470	1.730	9.862	F=W
Winter, 78	108	2.685	1.545	p<.0001	F≠S
Spring, 79	50	3.660	1.955		W≠S
ELECTRICITY AND MAGNETISM					
Fall, 78	198	3.546	1.924	21.531	F≠W
Winter, 78	108	4.991	2.085	p<.0001	F≠S
Spring, 79	50	4.720	1.800		W=S
WAVE MOTION AND LIGHT					
Fall, 78	198	1.641	1.157	13.777	F≠W
Winter, 78	108	2.370	1.633	p<.0001	F≠S
Spring, 79	50	2.440	1.343		W=S
ATOMIC AND NUCLEAR PHYSICS					
Fall, 78	198	1.770	0.974	22.792	F≠W
Winter, 78	108	1.806	1.211	p<.0001	F≠S
Spring, 79	50	2.140	1.010		W=S
KINETIC-MOLECULAR					
Fall, 78	198	1.308	1.043	9.346	F≠W
Winter, 78	108	1.843	0.968	p<.0001	F=S
Spring, 79	50	1.540	1.110		W=S
KNOWLEDGE					
Fall, 78	198	2.626	1.345	26.935	F≠W
Winter, 78	108	3.870	1.708	p<.0001	F≠S
Spring, 79	50	3.520	1.418		W=S
UNDERSTANDING					
Fall, 78	198	4.424	2.523	37.176	F≠W
Winter, 78	108	7.093	2.966	p<.0001	F≠S
Spring, 79	50	6.620	3.155		W=S
APPLICATION					
Fall, 78	198	3.091	1.880	14.226	F=W
Winter, 78	108	2.731	1.722	p<.0001	F≠S
Spring, 79	50	4.360	1.675		W≠S
TOTAL TEST					
Fall, 78	198	10.141	4.361	30.504	F≠W
Winter, 78	108	13.694	4.968	p<.0001	F≠S
Spring, 79	50	14.500	4.769		W=S

Fall (F)
Winter (W)
Spring (S)

TABLE IX

LOCALIZED COGNITIVE TEST GROUP MEAN COMPARISONS FOR YEAR 2 PHYSICS 131 STUDENTS BY ONE WAY ANALYSIS OF VARIANCE AND TUKEY'S HSD TEST

SUB-TEST GROUP BY DATE	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
MECHANICS					
Fall, 77	139	2.388	1.467	34.845	F≠W
Winter, 77	77	3.442	1.874	p<.0001	F≠S
Spring, 78	28	5.214	2.283		W≠S
ELECTRICITY AND MAGNETISM					
Fall, 77	139	3.029	1.773	27.691	F=W
Winter, 77	77	3.208	2.080	p<.0001	F≠S
Spring, 78	28	5.929	2.035		W≠S
WAVE MOTION AND LIGHT					
Fall, 77	139	1.288	0.965	36.776	F≠W
Winter, 77	77	1.701	1.298	p<.0001	F≠S
Spring, 78	28	3.321	1.492		W≠S
ATOMIC AND NUCLEAR PHYSICS					
Fall, 77	139	0.986	0.860	11.937	F=W
Winter, 77	77	1.234	1.012	p<.0001	F≠S
Spring, 78	28	1.929	1.274		W≠S
KINETIC-MOLECULAR					
Fall, 77	139	0.971	0.884	28.974	F≠W
Winter, 77	77	1.857	1.048	p<.0001	F≠S
Spring, 78	28	2.071	1.120		W=S
KNOWLEDGE					
Fall, 77	139	2.302	1.202	25.206	F≠W
Winter, 77	77	3.312	1.772	p<.0001	F≠S
Spring, 78	28	4.143	1.533		W≠S
UNDERSTANDING					
Fall, 77	139	3.935	2.191	53.602	F≠W
Winter, 77	77	5.753	2.647	p<.0001	F≠S
Spring, 78	28	9.071	3.310		W≠S
APPLICATION					
Fall, 77	139	2.424	1.602	37.656	F=W
Winter, 77	77	2.377	1.522	p<.0001	F≠S
Spring, 78	28	5.250	2.030		W≠S
TOTAL TEST					
Fall, 77	139	8.662	3.833	58.399	F≠W
Winter, 77	77	11.442	4.797	p<.0001	F≠S
Spring, 78	28	18.464	6.040		W≠S

Fall (F)
Winter (W)
Spring (S)

TABLE X

LOCALIZED COGNITIVE TEST GROUP MEAN COMPARISONS FOR YEAR 3 PHYSICS 131 STUDENTS BY ONE WAY ANALYSIS OF VARIANCE AND TUKEY'S HSD TEST

SUB-TEST GROUP BY DATE	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
MECHANICS					
Fall, 78	138	2.870	1.840	31.148	F=W
Winter, 78	84	3.369	1.795	p<.0001	F≠S
Spring, 79	26	6.000	2.117		W≠S
ELECTRICITY AND MAGNETISM					
Fall, 78	138	3.827	1.918	5.566	F=W
Winter, 78	84	4.286	2.132	p=.0043	F≠S
Spring, 79	26	5.192	1.898		W=S
WAVE MOTION AND LIGHT					
Fall, 78	138	1.927	1.294	19.821	F=W
Winter, 78	84	2.012	1.217	p<.0001	F≠S
Spring, 79	26	3.577	1.027		W≠S
ATOMIC AND NUCLEAR PHYSICS					
Fall, 78	138	1.326	1.005	16.248	F=W
Winter, 78	84	1.476	1.177	p<.0001	F≠S
Spring, 79	26	2.615	0.941		W≠S
KINETIC-MOLECULAR					
Fall, 78	138	1.304	0.944	19.757	F≠W
Winter, 78	84	2.214	1.193	p<.0001	F=S
Spring, 79	26	1.538	0.811		W≠S
KNOWLEDGE					
Fall, 78	138	2.848	1.356	26.111	F=W
Winter, 78	84	3.929	1.641	p<.0001	F≠S
Spring, 79	26	4.654	0.977		W=S
UNDERSTANDING					
Fall, 78	138	4.899	2.727	23.136	F≠W
Winter, 78	84	6.524	2.581	p<.0001	F≠S
Spring, 79	26	8.423	2.745		W≠S
APPLICATION					
Fall, 78	138	3.507	1.942	24.917	F=W
Winter, 78	84	2.405	1.733	p<.0001	F≠S
Spring, 79	26	5.846	1.804		W≠S
TOTAL TEST					
Fall, 78	138	11.254	4.806	30.387	F≠W
Winter, 78	84	13.357	4.715	p<.0001	F≠S
Spring, 79	26	18.923	3.773		W≠S

Fall (F)
Winter (W)
Spring (S)

SECTION IV

AFFECTIVE RESULTS AND FINDINGS

A second goal of the CAUSE project was to . . . "improve the attitude of the student toward the study of science in general and physics in particular." It was assumed that the attitudinal increment would reflect the pleasant and modern facilities of the Physics Instructional Center and the flexibility of the Individualized Investigation Approach.

The affective area was measured at each of the three yearly testing periods. The measuring instrument consisted of 31 Likert-type scale items which reflected attitudes toward science. A factor analysis of the scale identified five distinct factors: (1) attitude toward science, (2) attitude toward laboratory, (3) use of audio-visual materials, (4) attitude toward this class, and (5) attitude toward teacher. The analysis of the results of the data obtained from this scale were presented by factor as well as by total score. The scale appears in Appendix A of this report.

The scale for this measure is a one to five Likert scale ranging from one, "strongly disagree" to five, "strongly agree." The actual responses were added to obtain the reported scores. A higher score represented a more positive attitude toward the factor. A total score reliability in excess of .8 was computed each Fall during the first and third years of the project. The Kuder-Richardson formula was utilized to determine reliability.

The first year of the project was used to collect baseline data. The student attitudinal means and standard deviations for this period are presented in TABLE XI. Inspection of the data generally supported the original contention of the Project CAUSE proposal which stated that student attitudes ranged from somewhat "apathetic to negative" toward their laboratory experiences. These attitudes tended to be reflected in each of the factors of the affective measure during the baseline period.

The data found in TABLES XII and XIII represent the Year II and Year III affective mean scores for students from the four service courses. Each table contains student means and standard deviations for each attitude factor which may be compared for the two Project CAUSE implementation years. Inspection of TABLE XII reflects two significant changes on "Total" affective test scores for Year II. Both Physic 131 and 141 students showed a significant decrease in attitude mean score between Fall and Winter testings which was largely offset by mean score gains registered at the time of the final testing in the Spring. Some observations were made by the evaluators concerning the difficulties in initial implementation of the "IIA" which might be related to the number of declines between Fall and Spring attitudinal mean scores among Physics 131 students. These comments may be found in Section V of this report. It should be noted that 171 students were not involved in the PIC program, however, a signi-

ficant Fall to Winter attitudinal increment was registered. Other changes for Year II were not definitive.

Generally, no trends were observable from the affective scores data discussed above. A more rigorous analysis was attempted for all service courses. The analysis summary data may be found for Year II in TABLES XIV - XVII and Year III in TABLES XVII - XXI. The affective mean scores appeared to be stable during each of the two implementation years for all service courses. Again, no positive or negative trends were identifiable.

In summary, the goal concerning attitudinal improvement did not appear to be attained. While some changes were present it was felt that they were minimal. No significant increases or decreases were identifiable as trend factors.

TABLE XI

MEANS AND STANDARD DEVIATIONS
OF AFFECTIVE MEASURE
FOR YEAR ONE (1976-1977)

CLASS	FALL, 1976		WINTER, 1976		SPRING, 1977			
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	Difference Between Means Fall-Winter	Difference Between Means Winter-Spring
				Attitude Toward Science				
121/122	18.6	3.5	21.3	3.7	18.8	4.4	2.7	- 2.5*
131/132	19.4	3.5	19.0	3.8	20.1	3.6	- 0.4*	1.1
141/142	19.3	3.4	20.1	3.8	20.1	4.5	.8	0.0
171/172	21.9	3.6	23.3	3.2	21.9	3.9	1.4	- 1.4*
				Attitude Toward Laboratory				
121/122	15.7	2.4	14.9	3.4	16.5	3.0	- 0.8*	1.6
131/132	15.4	2.7	13.6	3.2	15.1	3.2	- 1.8*	1.5
141/142	16.2	2.5	14.4	3.3	15.7	3.0	- 1.8*	1.3
171/172	15.7	2.7	15.5	3.9	14.5	3.4	- 0.2*	- 1.0*
				Use of Audio-Visual Materials				
121/122	12.2	2.5	15.3	3.0	14.1	3.2	3.1	- 1.2*
131/132	13.2	2.0	13.5	3.2	14.6	2.4	0.3	1.1
141/142	11.8	1.7	13.4	2.9	13.1	3.0	1.6	- 0.3*
171/172	11.8	2.5	16.6	1.5	14.8	2.5	4.8	- 1.8*
				Attitude Toward This Class				
121/122	29.9	5.4	28.6	4.7	26.8	6.1	- 1.3*	- 1.8*
131/132	30.4	4.8	29.2	5.1	29.7	4.9	- 1.2*	0.5
141/142	33.4	4.8	33.2	4.2	33.7	3.8	- 0.2*	0.5
171/172	33.9	6.4	34.9	2.7	33.9	5.1	1.0	- 1.0*
				Attitude Toward Teacher				
121/122	29.9	2.9	30.9	4.4	30.1	4.4	1.0	- 0.8*
131/132	30.2	3.2	28.4	3.5	29.7	3.7	- 1.8*	1.3
141/142	30.4	3.2	29.5	3.3	30.6	4.0	- 0.9*	1.1
171/172	30.4	4.8	30.3	2.9	30.2	3.2	- 0.1*	- 0.1*
				TOTAL				
121/122	106.3	11.8	111.0	12.6	106.3	15.5	4.7	3.7*
131/132	108.6	10.3	103.7	11.5	109.2	10.9	4.9*	5.5
141/142	111.1	8.6	110.6	10.3	113.2	11.6	0.5*	2.6
171/172	113.7	14.6	120.6	8.0	115.3	11.7	6.9	5.3*

*Denotes a less positive attitude.

TABLE XII

MEANS AND STANDARD DEVIATIONS
OF AFFECTIVE MEASURE
FOR YEAR TWO (1977-1978)

CLASS	FALL, 1977		WINTER, 1977		SPRING, 1978			
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	Difference Between Means Fall-Winter	Difference Between Means Winter-Spring
				Attitude Toward Science				
121/122	18.3	2.6	17.8	4.2	17.1	4.1	- .5	- .7
131/132	18.8	3.0	18.9	5.3	19.2	5.5	.1	.3
141/142	20.2	3.6	18.2	7.0	20.7	4.7	- 2.0	2.5
171/172	19.2	2.7	23.3	2.9	23.2	3.3	4.1	- .1
				Attitude Toward Laboratory				
121/122	15.8	1.6	15.4	4.7	15.9	4.7	- .4	.5
131/132	15.8	2.4	10.1	4.8	14.8	5.5	- 5.7	4.7
141/142	15.9	2.8	15.7	6.2	16.0	5.4	- .2	.3
171/172	15.6	2.1	17.1	4.6	16.0	4.5	1.5	- 1.1
				Use of Audio-Visual Materials				
121/122	12.7	1.8	13.9	3.2	13.7	2.9	1.2	- .2
131/132	12.8	1.5	12.6	3.7	13.2	3.9	- .2	.6
141/142	12.2	2.1	11.4	4.6	15.5	2.6	- .8	4.1
171/172	12.4	2.1	16.1	1.9	16.6	2.0	3.7	.5
				Attitude Toward This Class				
121/122	27.6	5.1	26.4	6.3	26.5	5.4	- 1.2	.1
131/132	29.2	5.3	28.1	6.9	28.4	7.7	- 1.1	.3
141/142	32.7	6.2	29.9	10.0	33.5	4.6	- 2.8	3.6
171/172	32.8	6.0	35.3	3.2	34.2	4.6	2.5	- 1.1
				Attitude Toward Teacher				
121/122	25.4	2.8	26.0	4.4	25.9	3.9	1.6	- .1
131/132	25.5	2.9	26.4	5.7	26.3	6.0	- .9	- .1
141/142	25.5	3.9	24.5	8.1	27.1	3.3	- 1.0	2.6
171/172	24.9	3.7	29.2	3.4	28.9	2.7	4.3	- .3
				TOTAL				
121/122	99.8	8.7	99.5	17.6	99.1	13.7	0.8	- 0.4
131/132	102.11	10.2	96.1	21.6	101.9	22.9	- 6.0*	5.8*
141/142	106.5	16.0	99.7	16.1	112.8	16.3	- 6 8*	13.1*
171/172	104.9	13.4	121.7	11.2	118.9	12.1	16.1*	- 2.1

* $p < .05$

TABLE XIII

MEANS AND STANDARD DEVIATIONS
OF AFFECTIVE MEASURE
FOR YEAR THREE (1978-1979)

CIASS	FALL, 1978		WINTER, 1978		SPRING, 1979			
	X	S.D.	X	S.D.	X	S.D.	Difference Between Means Fall-Winter	Difference Between Means Winter-Spring
Attitude Toward Science								
121/122	18.3	3.2	19.2	4.6	17.2	4.9	0.9	- 2.0*
131/132	18.7	3.1	20.6	3.7	18.2	4.4	1.9*	- 2.4*
141/142	19.7	2.5	19.1	4.1	17.7	3.8	- 0.6	- 1.4*
171/172	20.4	3.0	21.2	6.1	21.1	4.1	0.8	- 0.1
Attitude Toward Laboratory								
121/122	17.5	3.0	16.0	4.8	14.8	4.6	- 1.5 *	- 1.2
131/132	17.1	3.1	17.2	4.0	17.1	3.9	0.1	- 0.1
141/142	17.2	2.3	16.8	4.4	15.3	3.9	- 0.4	- 1.5 *
171/172	16.8	3.1	17.7	5.0	18.0	3.8	0.9	0.3
Use of Audio-Visual Materials								
121/122	13.8	2.3	12.9	3.8	11.9	4.3	- 0.9 *	- 1.0
131/132	13.8	2.3	15.0	2.4	13.1	3.4	1.2 *	- 1.9 *
141/142	13.0	1.3	13.5	6.6	13.4	2.6	0.5	- 0.2
171/172	12.9	1.5	12.8	4.1	13.7	2.7	- 0.1	0.9
Attitude Toward This Class								
121/122	29.3	5.7	27.8	6.9	27.9	6.2	- 1.5	0.1
131/132	30.9	5.8	31.6	6.2	31.5	5.4	- 0.7	- 0.1
141/142	35.2	4.1	33.2	6.6	32.9	5.2	- 2.0	- 0.3
171/172	34.9	5.0	33.7	10.8	35.0	6.6	- 1.0	1.3
Attitude Toward Teacher								
121/122	22.0	3.5	21.2	4.1	19.9	3.6	- 0.8	- 1.3
131/132	22.3	3.3	21.9	2.9	21.7	2.6	- 0.4	- 0.2
141/142	22.7	2.2	22.4	3.9	21.3	3.4	- 0.3	- 1.1
171/172	22.9	2.6	22.0	5.9	23.5	3.0	- 0.9	1.5
TOTAL								
121/122	100.8	14.1	97.2	19.1	91.7	19.0	- 3.6	- 5.5
131/132	103.0	14.6	106.7	14.2	101.6	13.1	3.7	- 5.1
141/142	107.8	8.5	105.0	17.9	100.6	14.5	- 2.8 *	- 4.4 *
171/172	107.9	10.7	107.5	29.8	111.3	16.7	- 0.4	3.8

* $p < .05$

TABLE XIV

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR II PHYSICS 121 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 77	281	18.3	2.6	4.408	F=W
Winter, 77	147	17.8	4.2	p=.0126	F≠S
Spring, 78	89	17.1	4.1		W=S
FACTOR 2					
Fall, 77	281	15.8	1.6	0.856	F=W
Winter, 77	147	15.4	4.7	p=.4256	F=S
Spring, 78	89	15.9	4.7		W=S
FACTOR 3					
Fall, 77	281	12.7	1.8	13.449	F≠W
Winter, 77	147	13.9	3.2	p<.0001	F≠S
Spring, 78	89	13.7	2.9		W=S
FACTOR 4					
Fall, 77	281	27.6	5.1	2.858	F=W
Winter, 77	147	26.4	6.3	p=.0583	F=S
Spring, 78	89	26.5	5.4		W=S
FACTOR 5					
Fall, 77	281	25.4	2.8	1.667	F=W
Winter, 77	147	26.0	4.4	p=.1898	F=S
Spring, 78	89	26.9	3.9		W=S
TOTAL					
Fall, 77	281	99.8	8.7	.108	F=W
Winter, 77	147	99.5	17.6	.8973	F=S
Spring, 78	89	99.1	13.7		W=S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

TABLE XV

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR II PHYSICS 131 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 77	138	18.8	3.0	0.107	F=W
Winter, 77	79	18.9	5.3	p=.8990	F=S
Spring, 78	28	19.2	5.5		W=S
FACTOR 2					
Fall, 77	138	15.8	2.4	59.58	F≠W
Winter, 77	79	10.1	4.8	p<.001	F=S
Spring, 78	28	14.8	5.5		W≠S
FACTOR 3					
Fall, 77	138	12.8	1.5	0.512	F=W
Winter, 77	79	12.6	3.7	p=.6002	F=S
Spring, 78	28	13.2	3.9		W=S
FACTOR 4					
Fall, 77	138	29.2	5.3	0.885	F=W
Winter, 77	79	28.1	6.9	p=.4267	F=S
Spring, 78	28	28.4	7.7		W=S
FACTOR 5					
Fall, 77	138	25.5	2.9	1.201	F=W
Winter, 77	79	26.4	5.7	p=.3027	F=S
Spring, 78	28	26.3	6.0		W=S
TOTAL					
Fall, 77	138	102.1	10.2	3.559	F≠W
Winter, 77	79	96.1	21.6	p=.0300	F=S
Spring, 78	28	101.9	22.9		W=S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

TABLE XVI

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR II PHYSICS 141 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 77	75	20.2	3.6	3.313	F=W
Winter, 77	60	18.2	7.0	p=.0389	F=S
Spring, 78	32	20.7	4.7		W=S
FACTOR 2					
Fall, 77	75	15.9	2.8	0.049	F=W
Winter, 77	60	15.7	6.2	p=.9519	F=S
Spring, 78	32	16.0	5.4		W=S
FACTOR 3					
Fall, 77	75	12.2	2.1	16.866	F=W
Winter, 77	60	11.4	4.6	p=.0001	F≠S
Spring, 78	32	15.5	2.6		W≠S
FACTOR 4					
Fall, 77	75	32.7	6.2	3.223	F=W
Winter, 77	60	29.9	10.0	p=.0424	F=S
Spring, 78	32	33.5	4.6		W=S
FACTOR 5					
Fall, 77	75	25.5	3.9	2.175	F=W
Winter, 77	60	24.5	8.1	p=.1169	F=S
Spring, 78	32	27.1	3.3		W=S
TOTAL					
Fall, 77	75	106.5	16.0	7.316	F≠W
Winter, 77	60	99.7	16.1	.0009	F=S
Spring, 78	32	112.8	16.3		W≠S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

TABLE XVII

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR II PHYSICS 171 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 77	64	19.2	2.7	33.370	F≠W
Winter, 77	39	23.3	2.9	p=.0001	F≠S
Spring, 78	37	23.2	3.3		W=S
FACTOR 2					
Fall, 77	64	15.6	2.1	2.091	F=W
Winter, 77	39	17.1	4.6	p=.1275	F=S
Spring, 78	37	16.0	4.5		W=S
FACTOR 3					
Fall, 77	64	12.4	2.1	66.784	F≠W
Winter, 77	39	16.1	1.9	p<.0001	F≠S
Spring, 78	37	16.6	2.0		W=S
FACTOR 4					
Fall, 77	64	32.8	6.0	3.147	F≠W
Winter, 77	39	35.3	3.2	p=.0461	F=S
Spring, 78	37	34.2	4.6		W=S
FACTOR 5					
Fall, 77	64	24.9	3.7	26.329	F≠W
Winter, 77	39	29.2	3.4	p<.0001	F≠S
Spring, 78	37	28.9	2.7		W=S
TOTAL					
Fall, 77	64	104.9	13.4	25.610	F≠W
Winter, 77	39	121.0	11.2	p<.0001	F≠S
Spring, 78	37	118.9	12.1		W=S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

TABLE XVIII

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR III PHYSICS 121 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 78	210	18.3	3.2	4.704	F=W
Winter, 78	107	19.2	4.6	p=.0096	F=S
Spring, 79	51	17.2	4.9		W≠S
FACTOR 2					
Fall, 78	210	17.5	3.0	12.580	F≠W
Winter, 78	107	16.0	4.8	p<.0001	F≠S
Spring, 79	51	14.8	4.6		W=S
FACTOR 3					
Fall, 78	210	13.8	2.3	8.680	F≠W
Winter, 78	107	12.9	3.8	p=2.0002	F≠S
Spring, 79	51	11.9	4.3		W=S
FACTOR 4					
Fall, 78	210	29.3	5.7	2.580	F=W
Winter, 78	107	27.8	6.9	p=.0771	F=S
Spring, 79	51	27.9	6.2		W=S
FACTOR 5					
Fall, 78	210	22.0	3.5	7.040	F=W
Winter, 78	107	21.2	4.1	p=.0010	F≠S
Spring, 79	51	19.9	3.6		W=S
TOTAL					
Fall, 78	210	100.8	14.1	6.778	F=W
Winter, 78	107	97.2	19.1	p=.0013	F≠S
Spring, 79	51	91.7	19.0		W=S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

TABLE XIX

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR III PHYSICS 131 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 78	137	18.7	3.1	9.333	F≠W
Winter, 78	84	20.6	3.7	p<.0001	F=S
Spring, 79	28	18.2	4.4		W≠S
FACTOR 2					
Fall, 78	137	17.1	3.1	0.022	F=W
Winter, 78	84	17.2	4.0	p=.9778	F=S
Spring, 79	28	17.1	3.9		W=S
FACTOR 3					
Fall, 78	137	13.8	2.3	8.816	F≠W
Winter, 78	84	15.0	2.4	p<.0002	F=S
Spring, 79	28	13.1	3.4		W≠S
FACTOR 4					
Fall, 78	137	31.5	5.4	0.289	F=W
Winter, 78	84	31.9	6.2	.7496	F=S
Spring, 79	28	31.0	5.8		W=S
FACTOR 5					
Fall, 78	137	22.3	3.3	0.694	F=W
Winter, 78	84	21.9	2.9	p=.5005	F=S
Spring, 79	28	21.7	2.6		W=S
TOTAL					
Fall, 78	137	103.0	14.6	2.219	F=W
Winter, 78	84	106.7	14.2	p=.110	F=S
Spring, 79	28	101.6	13.1		W=S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

TABLE XX

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR III PHYSICS 141 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 78	86	19.7	2.5	6.642	F=W
Winter, 78	69	19.1	4.1	p=.0016	F≠S
Spring, 79	71	17.7	3.8		W≠S
FACTOR 2					
Fall, 78	86	17.2	2.3	5.928	F=W
Winter, 78	69	16.8	4.4	p=.0031	F≠S
Spring, 79	71	15.3	3.9		W≠S
FACTOR 3					
Fall, 78	86	13.0	1.3	0.307	F=W
Winter, 78	69	13.5	6.6	p=.7358	F=S
Spring, 79	71	13.3	2.6		W=S
FACTOR 4					
Fall, 78	86	35.2	4.1	4.433	F=W
Winter, 78	69	33.2	6.6	p=.0129	F≠S
Spring, 79	71	32.9	5.2		W=S
FACTOR 5					
Fall, 78	86	22.7	2.2	4.118	F=W
Winter, 78	69	22.4	3.9	p=.0175	F≠S
Spring, 79	71	21.3	3.3		W=S
TOTAL					
Fall, 78	86	107.8	8.5	5.298	F≠W
Winter, 78	69	105.0	17.9	p=.0057	F=S
Spring, 79	71	100.6	14.5		W≠S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

TABLE XXI

AFFECTIVE INSTRUMENT GROUP MEAN COMPARISONS
FOR YEAR III PHYSICS 171 STUDENTS
BY ONE WAY ANALYSIS OF VARIANCE
AND TUKEY'S HSD TEST

FACTORS	N	$\bar{X}$	S.D.	F (ALL GROUPS MEANS)	TUKEY'S HSD (.05)
FACTOR 1					
Fall, 78	66	20.4	3.0	0.537	F=W
Winter, 78	20	21.2	6.1	p=.5857	F=S
Spring, 79	40	21.1	4.1		W=S
FACTOR 2					
Fall, 78	66	16.8	3.1	1.451	F=W
Winter, 78	20	17.7	5.0	p=.2383	F=S
Spring, 79	40	18.0	3.8		W=S
FACTOR 3					
Fall, 78	66	12.9	1.5	1.530	F=W
Winter, 78	20	12.8	4.1	p=.2206	F=S
Spring, 79	40	13.7	2.7		W=S
FACTOR 4					
Fall, 78	66	34.9	5.0	0.289	F=W
Winter, 78	20	33.7	10.8	p=.7496	F=S
Spring, 79	40	35.0	6.6		W=S
FACTOR 5					
Fall, 78	66	22.9	2.6	1.285	F=W
Winter, 78	20	22.0	5.9	p=.2803	F=S
Spring, 79	40	23.5	3.0		W=S
TOTAL					
Fall, 78	66	107.9	10.7	0.586	F=W
Winter, 78	20	107.5	29.8	p=.5578	F=S
Spring, 79	40	111.3	16.7		W=S

Fall (F)
Winter (W)
Spring (S)

FACTORS

1 Attitude Toward Science
2 Attitude Toward Laboratory
3 Use of Audio-Visual Materials
4 Attitude Toward This Class
5 Attitude Toward Teacher

SECTION V

ANECDOTAL OBSERVATIONS AND FINDINGS

It is often difficult to depict all of the significant variables which produce changes or directly result from a three year project of this size and scope. From a research standpoint the quantitative data already discussed has assisted in providing conjecture regarding project impact. Unfortunately the space limitations of an evaluation report and the relative inflexibility of predetermined research procedures for quantitative measurement and analysis often do not allow for the discussion of other relevant observations.

Within the Purpose of the Evaluation section of this report it was stated that some of those observations and anecdotes believed to be most appropriate and valid would be discussed. This discussion was prepared for those wishing to replicate similar instructional modes or otherwise extend the findings of this project. This discussion will focus upon selected considerations for the planning, implementation, and evaluation of similar endeavors.

The first source of data for this section was based primarily upon interactions between the evaluator and project staff. These interactions began during the planning phases of the project and continued intermittantly over its three year duration.

A second source of data was anecdotal statements collected by the staff of the Center for Research and Evaluation (CRE). During the latter two project years CRE staff members would periodically station themselves in the PIC in an attempt to record observations and responses to opinion questions. It was felt that, although not random, these direct responses added a relevant and essentially descriptive dimension to this report.

This section will be organized around general topical areas reflecting the subsequent discussion.

STUDENT ADJUSTMENT PROBLEMS

The first problem area was encountered by staff and students during the initial implementation of the IIA. Problems were centered around a number of student adjustment factors regarding their responsibility to initiate their own laboratory investigations. Many students were accustomed to the traditionally scheduled instructor initiated didactic laboratory sequence. Although the staff made efforts to instruct students and special materials were prepared which were designed to facilitate implementation, the early weeks found many students delaying initiation of their investigations and some students falling well behind. Project staff members then placed some time limitations for completion of each specific investigation, which seemed to expedite student completions. It was also noted that as new students entered

the PIC courses during Year III this problem was substantially reduced at the outset. The latter improvement in student adjustment to the open PIC schedule was perhaps attributable to the time constraints and better student entering expectiations which resulted from their own informal communications.

EVALUATION OBSERVATIONS

The second area for discussion which was encountered during the implementation of the IIA was the general area of evaluation. Personal experience and familiarity with the literature concerning evaluation, the requirements of demonstration projects, and the nature of independent instructional approaches enabled the anticipation of three areas of potential pitfalls. Each of the three problem areas will be individually identified below and a general discussion of their resolution will follow.

First, for an institution of higher education to fulfill its on-going programatic functions some evaluations are required and inherently necessary. These evaluations include normal course examinations and subsequent issuance of students' grades. These required evaluative processes are expected by students and faculty. When intervening factors appear to influence this process or when the evaluative process becomes excessive then resistance to evaluation increases.

Second, a demonstration project must provide adequate evaluation data in order to determine efficacy, however, extensive data collection may provide a biasing factor. For example a project that requires extensive student input through tests, questionnaires, and other data gathering devices is apt to develop negative reactions to the devices themselves which may misrepresent the results of the project.

Third, individualized instructional approaches frequently require student self-evaluation which is in effect another type of evaluation. Self-evaluation was a part of the IIA and exerted the potential of negative biasing factors.

As indicated elsewhere in this report, the data gathered to determine project efficacy consisted of the three times per year affective and cognitive data collections. These data collections posed one problem of significance. The affective and cognitive instruments were administered in the large lecture sections. Due to instructor misunderstanding several sections were released which significantly contributed to the student attrition rate. It was necessary to emphasize that the data was needed, useful, and was not an evaluation of any individual efforts or performance. These assurances came with the endorsement of the department chairman.

Other data collected locally in relation to the project consisted of numerous short evaluations of specific newly developed instructional materials. Through utilization of

the on-going guidelines "keep it short" and "is it needed?" most project material evaluations were themselves under continual refinement. One method employed in reducing the frequence of individual student involvement was random selection. The project staff has stated a committment to continue this type of data collection.

The third area listed above as a potential pitfall was not completely resolved at the time of this report. The IIA format required that a student independently complete an investigation and then take an examination over that investigation. Some students perceived this as two levels of evaluation. First, they perceived the investigation as an evaluation that "doesn't count." Second, many referred to their investigation examination as the "weekly" test.

Some students also voiced concern over laboratory/lecture/test and even laboratory/test coordination stating that tests were not always related to labs. A project staff member stated that the function of the grader/tutor is essential to their program. While many perceived the teaching assistants and grader/tutors as helpful others felt that they should offer "more" assistance and be "eager" to give aid. Some areas of future exploration should include ways of providing flexibility of requirements related to the independent laboratory on subsequent examinations.

IMPLEMENTATION OBSERVATIONS

Project staff realized from the initial stages of the proposal preparation that to be successful careful planning, development and implementation of educational materials must take place. Although aware of this, the project staff continually were reminded that the preparation of the laboratory materials was a gradual process. The original plan called for complete implementation of the individualized laboratory materials to be available in all four service courses by the end of the first year. This was not possible.

Baseline data collection during the initial stages of the project produced information which demonstrated that the student populations enrolled in each of the four service courses differed markedly. The differences were not only found in prior experience in science coursework, but also included basic demographic differences and future interests. Consequently it was established that different materials must be developed to effectively meet the varied needs of students to be served within each of the service courses. In other words, an investigation covering magnitism for Physics 121 students should differ substantially from an investigation dealing with magnitism for Physics 171 students. These differences would reflect the sophistication in mathematics, physics terminology, and other experiences which would effect student understanding of physics content. These students'

differences then were accommodated through utilization of illustrations, examples, and applications appropriate to the specific student groups served.

The need to differentiate between the various courses as well as the time necessary to prepare and revise investigations prevented the anticipated full implementation of instructional materials in the four courses by the end of the third year of project CAUSE. The IIA was completed for Physics 141/142 in August, 1979. Other considerations, however, reversed the decision to include Physics 171/172 in the IIA. It was felt that the Physics 171/172 students demanded extensive and technical instruction better provided in a supervised laboratory. It should be noted that the Department of Physics will continue the laboratory IIA and the PIC through the support of personnel and material refinement to enable full utilization.

UNANTICIPATED FINDING

An unanticipated finding was that improved cognition may have been related inpart to process evaluation along with more rigid laboratory standards. More exacting attendance records along with rigorous laboratory procedures and grading standards were included in the IIA. This in turn meant that students were required to attend laboratory to pass, to individually complete work while in the laboratory, and to meet a set standard (80%) of content mastery. One grader/tutor

stated that grading is "stiffer" now so there may be no improvement in course grades but comprehension is up. Another grader reported that 80 per cent of the students pass the test the first time. It appeared that the IIA and the inherent evaluation format may have positively influenced student achievement and perhaps negatively influenced attitudes of those 20% of the students not passing the test the first time. The major unanticipated finding that improved cognition may have been strongly influenced by more rigorous standards rather than other factors within the IIA is noteworthy. Further the rigorousness of the grading may have influenced the relative lack of change in affective student scores observed.

OTHER ANECDOTES

General anecdotes and statements have been paraphrased within earlier portions of this section of the the report. It was felt that the anecdotes which follow were helpful in reflecting the general tenor found by the CRE observers.

Student attitudes toward IIA varied as reflected by student anecdotes. A number of students favorably compared the project CAUSE physics labs to labs taken in other science and education programs. "Physics labs are better than biology labs. I can absorb information better when viewing and hearing," reported an African international student. A transfer student

commented, "The lab set-up here is all right; better than my last school." Another student, who had first taken Physics four years earlier, said, "I like labs much better now. I can go at my own pace which helps."

Another positive point frequently mentioned was the PIC availability which permitted students self-scheduling. "I really like the availability of tapes and the PIC. When I have the time I can come in," one student stated. Another student mentioned, "The videotapes are good. I can stop the tape and go over any point I find confusing until I understand it." "The best thing is that I can do my lab when I feel like it, not at a specific time each week. I appreciate that," was the response of another student.

Other students found the individualized system less rewarding. One freshman Education major stated, "I wish they'd have set times for labs and make us go. I tend to fall behind on my own. The center is well organized and the tapes are good, but I'm not good at making myself go."

The issue of "individual" help for beginning students was recurring. A more advanced student working as a laboratory assistant stated, "Self-paced courses should be for the more advanced students. 121 and 131 students need more individual help."

A PIC grader/tutor offered these observations. "Students are not observing videotapes well, so the lab experience suffers. It is true that some lab instructors are not too clear so students are not understanding the labs well.

However, there have been less make-up tests this Fall (1978) and less complaints also. The workers are more used to the system now." This observation reflects the progress the IIA/PIC has made over its three year existence. The evaluators' observations concur with this statement. The IIA/PIC appears to be an efficient and effective learning environment. Students come in to work and learn. The decor is pleasant and employees helpful. With the proper adjustments based on student input and evaluation recommendations the PIC should establish itself as a model facility and the IIA continue as a viable scientific instructional format.

SECTION VI

SUMMARY

This Final Report has included measurement data and interpretations of the National Science Foundation sponsored Project CAUSE instituted by the Department of Physics at North Texas State University. Section I of this report included the goals of the project, a general description of the project, and the evaluation design. A description of the demographic, cognitive and affective data collected during the three project years are included in Sections II, III, and IV, respectively. Section V was a descriptive account of general anecdotes and observations gathered by the evaluators.

This section was based upon the previous data and interpretation found within this report. The function of this section was to succinctly list those conclusions and recommendations deemed appropriately related to Project CAUSE.

CONCLUSIONS

The final evaluation resulted in the following general conclusions.

1. The service courses were successfully serving their respective target student populations.
2. The provision of specific service courses for target student populations, such as business or education.

majors, appeared to be an effective means of providing appropriate science instruction to students who may have not been served.

3. The collective student populations of the service courses closely paralleled the student populations of North Texas State University.
4. Target course student populations remained quite stable over the three year project period.
5. Cognitive measures consistantly reflected acquisition of appropriate knowledge of Physics when consideration was given to the subject content covered in specific service courses.
6. Indicators of student cognitive retention and comprehension were positive in service courses where the individualized instructional format was fully implemented.
7. No general changes were found in measured student affective scores during the three year project.
8. Evaluator observations noted a continual improvement in the utilization and effectiveness of the instructional services of the Physics Instructional Center.
9. Materials developed for specific service courses were utilized as alternative presentations in other physics courses.

10. The Physics Department appeared committed to continue, refine, evaluate, and improve the program described in this report.

RECOMMENDATIONS

Other findings, data interpretations, and observations permitted the following recommendations.

1. If an adequately large student population can be established and student attrition controlled to accommodate the number of predictor variables under consideration, a multi-variant linear regression model would be an effective method of evaluating a similar project. When smaller numbers of students are available, a predetermined number of matched pair comparisons may assist in controlling for attrition.
2. The process of developing, implementing, and refining instructional materials is a time consuming and difficult process. Sufficient time along with personnel descriptions, responsibilities, and evaluation should be carefully built into project planning and monitoring.
3. Rigidly enforced attendance and independent completion of laboratory assignments should be considered as a variable in future projects dealing with independent study.

4. Criterion referenced formative evaluations may be considered as an alternative to the evaluation processes required within the individualized investigations. This format would provide direct feedback to students which would assist them in determining whether their mastery of content was at an appropriate level. These evaluations can be either self or proctor administered.
Less frequently administered criterion referenced summative examinations may be required to demonstrate content mastery. This type of formal evaluation permits students to review content and retake examinations when necessary on only those content areas where predetermined performance levels were not attained.

APPENDIX A

DO NOT WRITE ON THIS FORM

Please answer these questions regarding your feelings about this class. Complete each item by filling in the appropriate space on the computer answer sheet. Be sure to fill out the identification number on the answer sheet with your social security number.

Use this scale to determine your answer:

1	2	3	4	5
strongly disagree	disagree	undecided	agree	strongly agree

1. I enjoy this course more than other courses.
2. There are more opportunities to discuss the subject in class than in most other courses.
3. The laboratory experiences made me think.
4. Most of our class time is spent in answering questions that are in the textbook or study guide.
5. The experiments done by the laboratory are relevant to me.
6. We are expected to learn most of the details from the textbook.
7. Homework or independent study assignments are clearly related to class objectives.
8. I dislike this course.
9. Films, audio-tapes, filmstrips, or other types of audio-visual equipment are used in this class more than most others.
10. Laboratory has no relation to classwork.
11. Students are discouraged rather than encouraged to participate during class.
12. The organization of my laboratory enables me to perform satisfactorily.
13. My teacher tries to make clear the purpose or objectives of a unit before we begin to study.
14. I look forward to this class.

15. I can get individual help for my classwork.

16. I know what is expected of me in this class.

17. Laboratory directions are always clear.

18. The films and outside materials used for this class are very helpful.

19. I like to do the laboratory experiments myself.

20. The study of physics will help me in the future.

21. The advantages of studying science outweigh the disadvantages.

22. This class is not worthwhile to me.

23. I would never take a science course if it wasn't required.

24. We have too much "busy work" in this class.

25. The teacher does not utilize enough available audio-visual resources in teaching this class.

26. I enjoy studying science.

27. Students should not be forced to take science courses.

28. This subject is not relevant to me.

29. Science makes natural phenomena more relevant to my personal life.

30. The emphasis in this class is in finding the right answer rather than exporing student ideas.